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Frank

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(54) **RADIATION DIRECTIONAL FINDER AND ISOTOPE IDENTIFICATION SYSTEM**

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(58) **Field of Classification Search** 250/370.01, 250/370.05, 370.1, 394
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,158,773	A	6/1979	Novak
4,799,828	A	1/1989	Georgii
5,056,958	A	10/1991	Campbell
5,241,573	A	8/1993	Thacker
5,633,508	A	5/1997	Schleppenbach
5,665,970	A	9/1997	Kronenberg et al.
5,838,759	A	11/1998	Armistead

(Continued)

FOREIGN PATENT DOCUMENTS

KR 10-1992-7004134 12/1992

(Continued)

OTHER PUBLICATIONS

U.S. Appl. No. 11/291,574, filed Dec. 2005, Frank.

(Continued)

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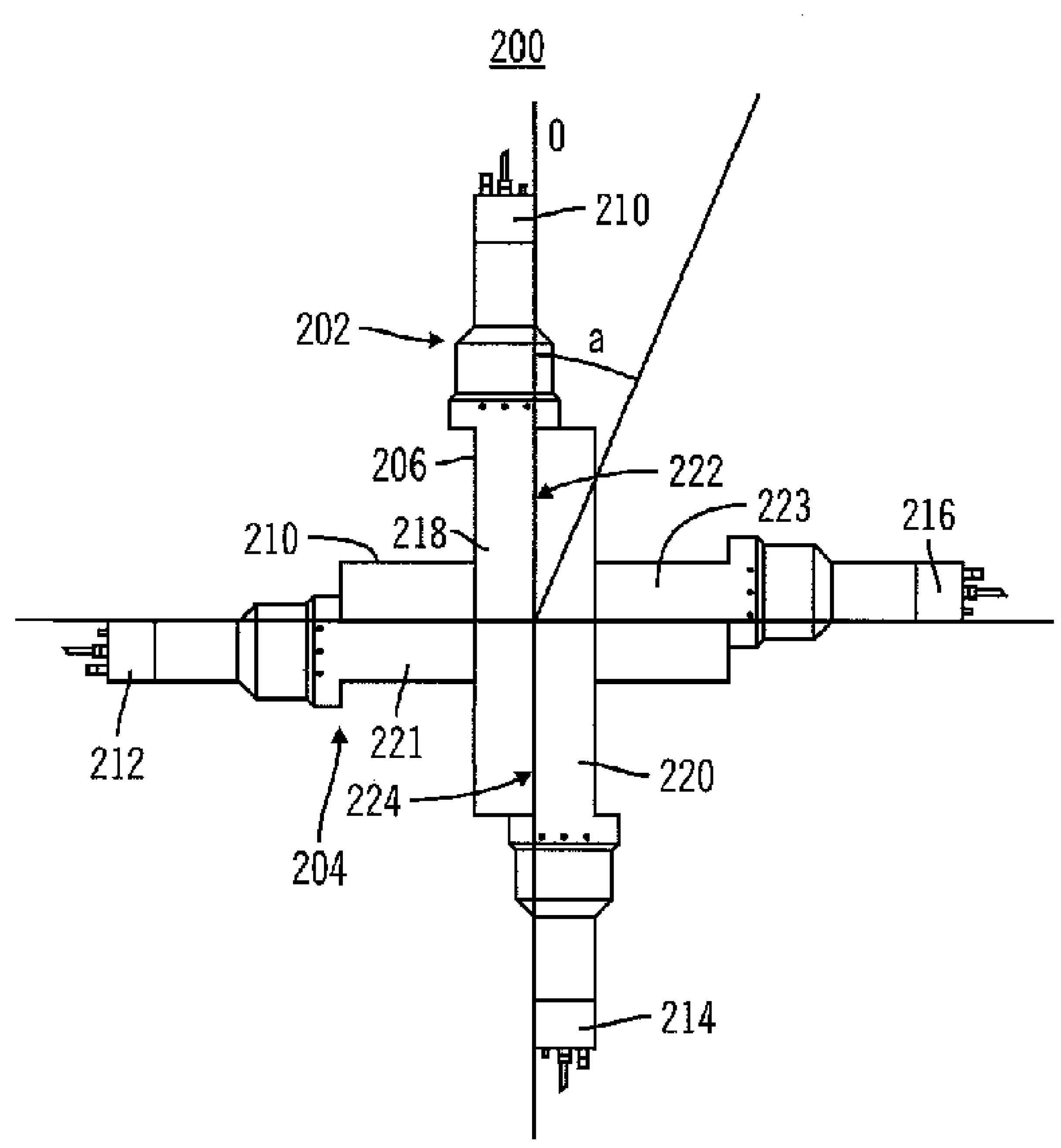
(57) **ABSTRACT**

A system and method determine a direction associated with gamma and/or neutron radiation emissions. A first radiation photon count associated with a first detector in a detector set is received from the first detector. The first radiation photon count is associated with at least one radiation source. A second radiation photon count associated with a second detector in the detector set is received from the second detector. The first radiation photon count is compared to the second radiation photon count. One of the first detector and the second detector is identified to have detected a larger number of radiation photons than the other. The at least one radiation source is determined to be substantially in a direction in which the one of the first detector and the second detector that has detected the larger number of radiation photons is facing.

20 Claims, 6 Drawing Sheets



U.S. PATENT DOCUMENTS

6,370,222	B1	4/2002	Cornick	
6,433,335	B1	8/2002	Kronenberg et al.	
6,479,826	B1	11/2002	Klann et al.	
6,545,281	B1	4/2003	McGregor et al.	
6,845,873	B1	1/2005	Chattey	
6,891,470	B2	5/2005	Bohinc	
6,937,692	B2	8/2005	Johnson	
6,980,483	B2	12/2005	McDonald	
6,998,617	B2	2/2006	D'Emilio et al.	
7,026,944	B2	4/2006	Alioto et al.	
7,030,755	B2	4/2006	Bohinc	
7,064,333	B2 *	6/2006	Torii	250/361 R
7,064,336	B2	6/2006	Archer et al.	
7,116,235	B2	10/2006	Alioto et al.	
7,151,447	B1	12/2006	Willms et al.	
7,183,554	B2	2/2007	Gallagher et al.	
7,356,115	B2	4/2008	Ford et al.	
2002/0175291	A1	11/2002	Reeder et al.	
2003/0108150	A1	6/2003	Franke	
2003/0144800	A1	7/2003	Davis et al.	
2003/0165211	A1	9/2003	Lee et al.	
2003/0201394	A1	10/2003	Peoples	
2004/0018060	A1	1/2004	Knezek et al.	
2004/0054248	A1 *	3/2004	Kimchy et al.	600/3
2004/0119591	A1	6/2004	Peeters	
2004/0126895	A1	7/2004	Overbeck et al.	
2004/0148137	A1	7/2004	Zerwekh et al.	
2005/0011849	A1	1/2005	Chattey	
2005/0023477	A1	2/2005	Archer et al.	
2005/0082485	A1	4/2005	Tatsuo	
2005/0156734	A1	7/2005	Zerwekh et al.	
2005/0205793	A1	9/2005	Bohinc	
2005/0220247	A1	10/2005	Ruddy et al.	
2005/0258372	A1	11/2005	McGregor et al.	
2005/0275545	A1	12/2005	Alioto et al.	
2006/0097171	A1	5/2006	Balchunas et al.	
2006/0138331	A1	6/2006	Guillebaud et al.	
2006/0284094	A1	12/2006	Inbar	
2007/0001123	A1	1/2007	Andrews et al.	

FOREIGN PATENT DOCUMENTS

KR	10-1005-0067392	7/2005
WO	WO98-00681	1/1998
WO	WO2006-085999	8/2006

OTHER PUBLICATIONS

U.S. Appl. No. 11/363,594, filed Feb. 2006, Frank.
U.S. Appl. No. 11/564,193, filed Nov. 2006, Frank.
U.S. Appl. No. 11/931,370, filed Oct. 2007, Frank.
International Preliminary Report on Patentabiilty for PCT/US06/46255 mailed Sep. 24, 2008.
International Search Report and Written Opinion of the International Searching Authority for PCT/US06/46255 mailed Sep. 25, 2007.
Written Opinion of the International Searching Authority for PCT/US07/085578 dated Jan. 23, 2009.
International Search Report for PCT/US07/085578 dated Jan. 23, 2009.
PCT Application No. PCT/US2007/085578 filed Nov. 27, 2007.
PCT Application No. PCT/US2006/46255 filed Nov. 30, 2006.
Non-Final Rejection for U.S. Appl. No. 11/291,574 dated Dec. 2, 2008.
Final Rejection for U.S. Appl. No. 11/291,574 dated Mar. 20, 2008.
Notice of Allowance for U.S. Appl. No. 11/291,574 dated May 20, 2009.
Non-Final Rejection for U.S. Appl. No. 11/363,594 dated Aug. 23, 2006.
Notice of Allowance for U.S. Appl. No. 11/363,594 dated Sep. 27, 2006.
Non-Final Rejection for U.S. Appl. No. 11/564,183 dated Jun. 25, 2009.
Non-Final Rejection for U.S. Appl. No. 11/931,370 dated Dec. 12, 2008.
Final Rejection for U.S. Appl. No. 11/931,370 dated Sep. 9, 2009.
Final Rejection for U.S. Appl. No. 11/564,193 dated Jan. 8, 2010.
Notice of Allowance for U.S. Appl. No. 11/930,229 dated Apr. 7, 2010.
International Search Report and Written Opinion for PCT/US09/050299 dated Mar. 3, 2010.
Notice of Allowance for U.S. Appl. No. 11/931,370 dated Mar. 30, 2010.
International Search Report for PCT/US09/038064 dated Jul. 31, 2009.
International Search Report and Written Opinion for PCT/US09/044486 dated Dec. 23, 2009.
International Search Report and Written Opinion for PCT/US09/044475 dated Jan. 6, 2010.
International Search Report and Written Opinion for PCT/US09/045268 dated Jan. 29, 2010.
International Search Report and Written Opinion for PCT/US09/044494 dated Jan. 18, 2010.
Non-Final Rejection for U.S. Appl. No. 11/931,211 dated Apr. 30, 2010.
International Search Report and Written Opinion dated Jan. 6, 2010 for PCT/US2009/044475.

* cited by examiner

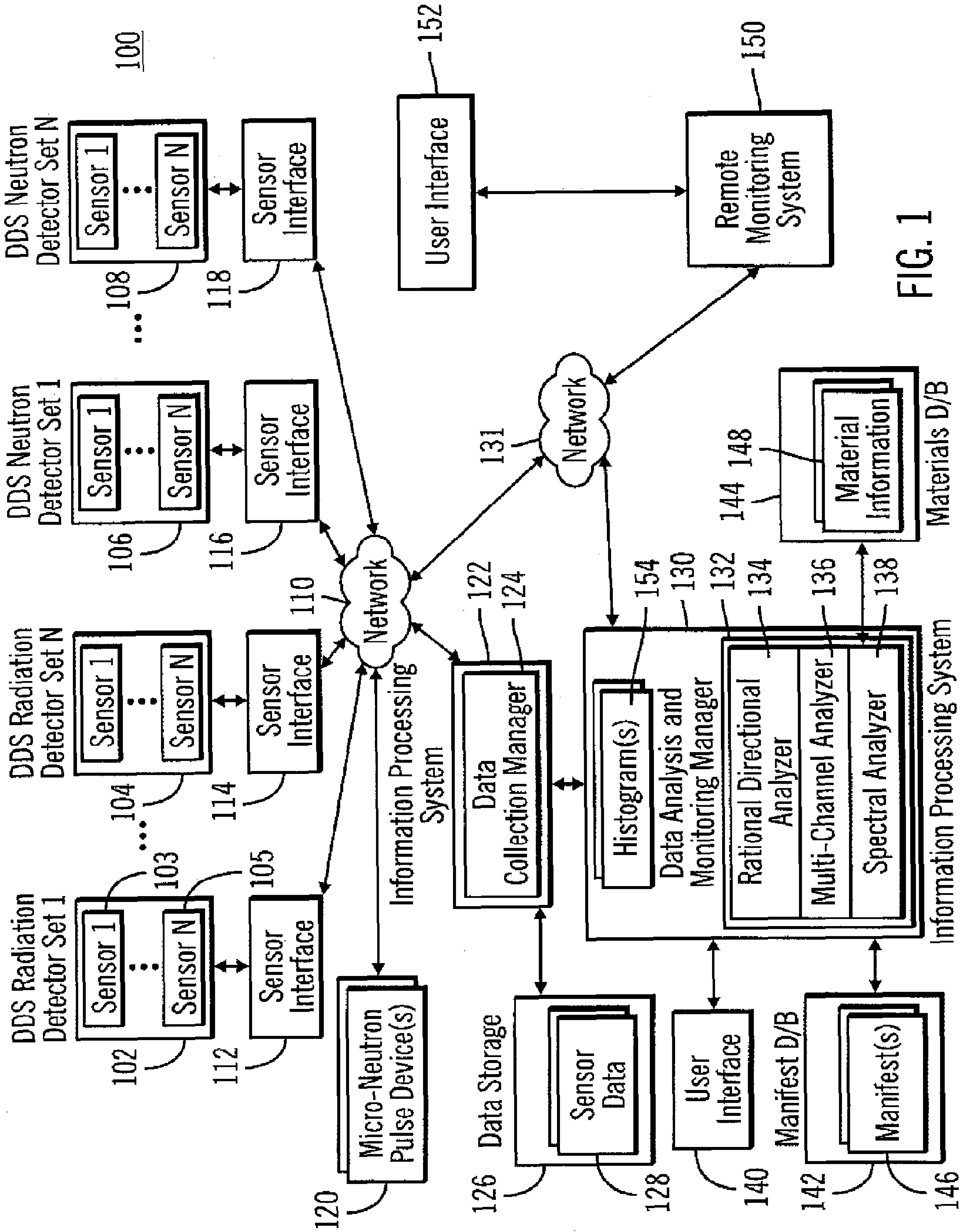

100
DDS Radiation Detector Set 1
Sensor 1
Sensor N
102
103
105
112
Sensor Interface
DDS Radiation Detector Set N
104
114
DDS Neutron Detector Set 1
106
116
DDS Neutron Detector Set N
108
118
Network
110
Micro-Neutron Pulse Device(s)
120
Information Processing System
Data Collection Manager
122
124
Data Storage
Sensor Data
126
128
User Interface
140
Manifest D/B
Manifest(s)
142
146
Histogram(s)
154
Data Analysis and Monitoring Manager
130
Rational Directional Analyzer
132
134
Multi-Channel Analyzer
136
Spectral Analyzer
138
Information Processing System
Network
131
Materials D/B
Material Information
144
148
User Interface
152
Remote Monitoring System
150

FIG. 1

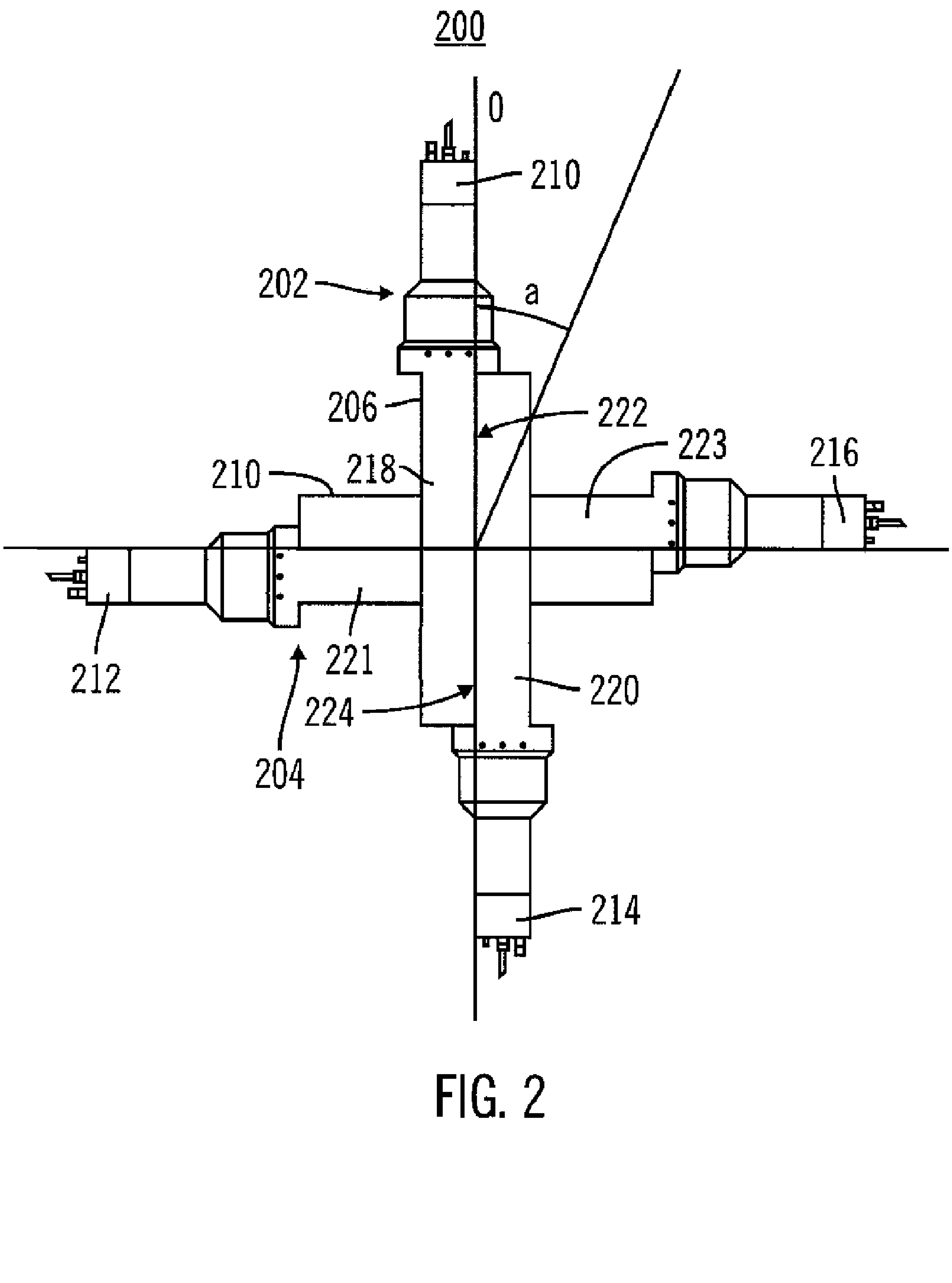


FIG. 2

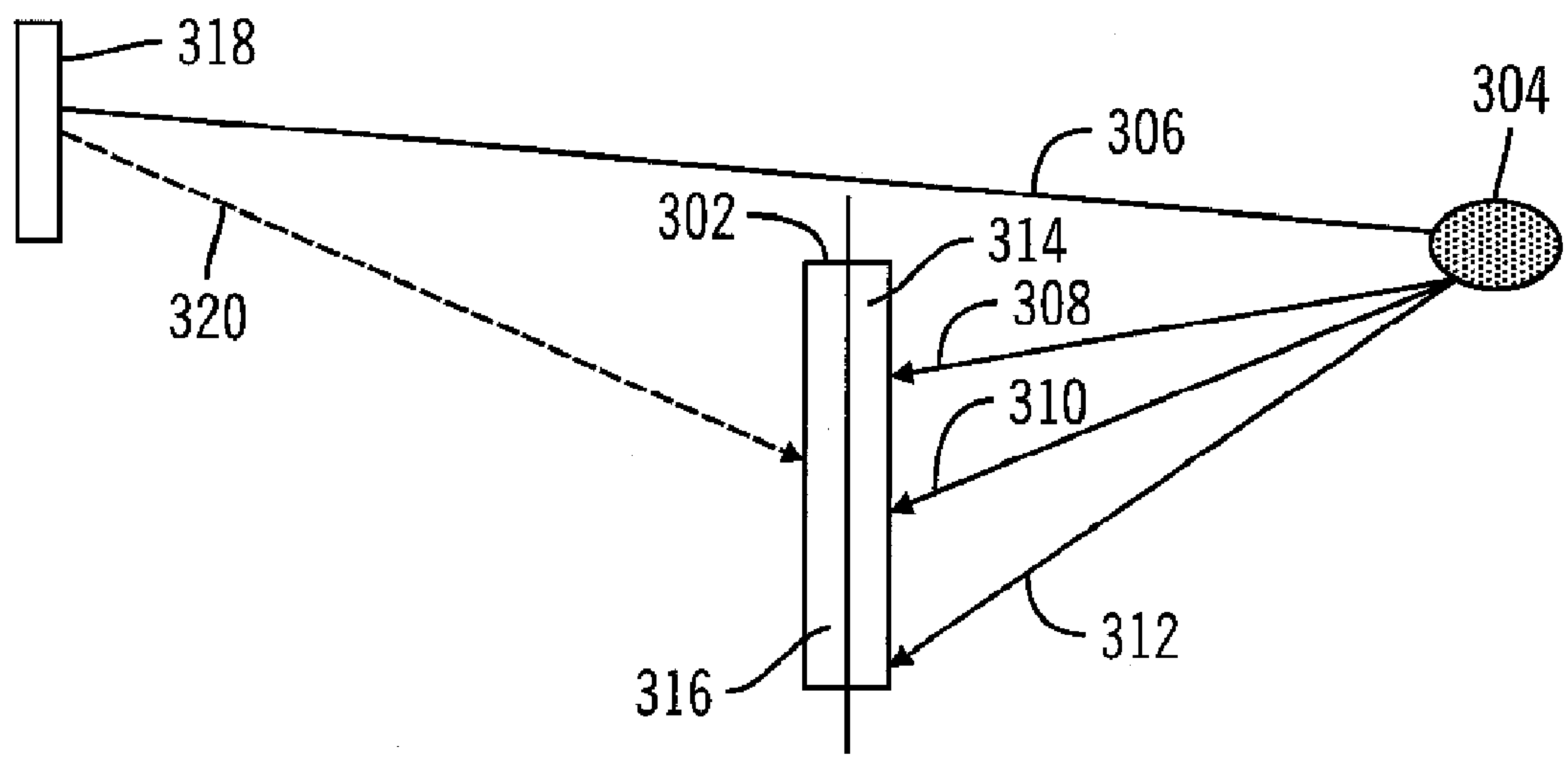


FIG. 3

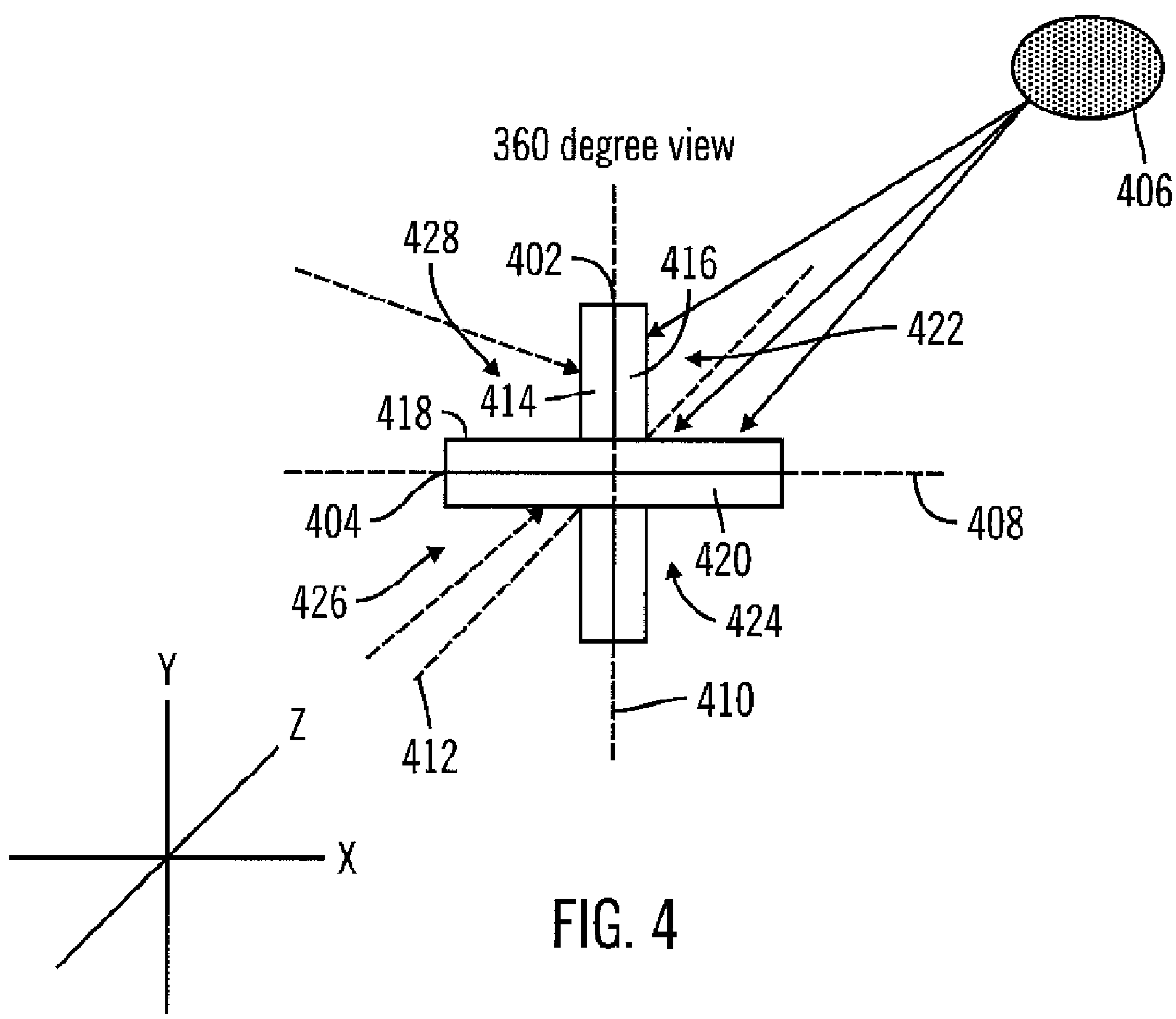

360 degree view
406
428
402
416
422
414
418
404
408
420
426
424
410
412
Y
Z
X

FIG. 4

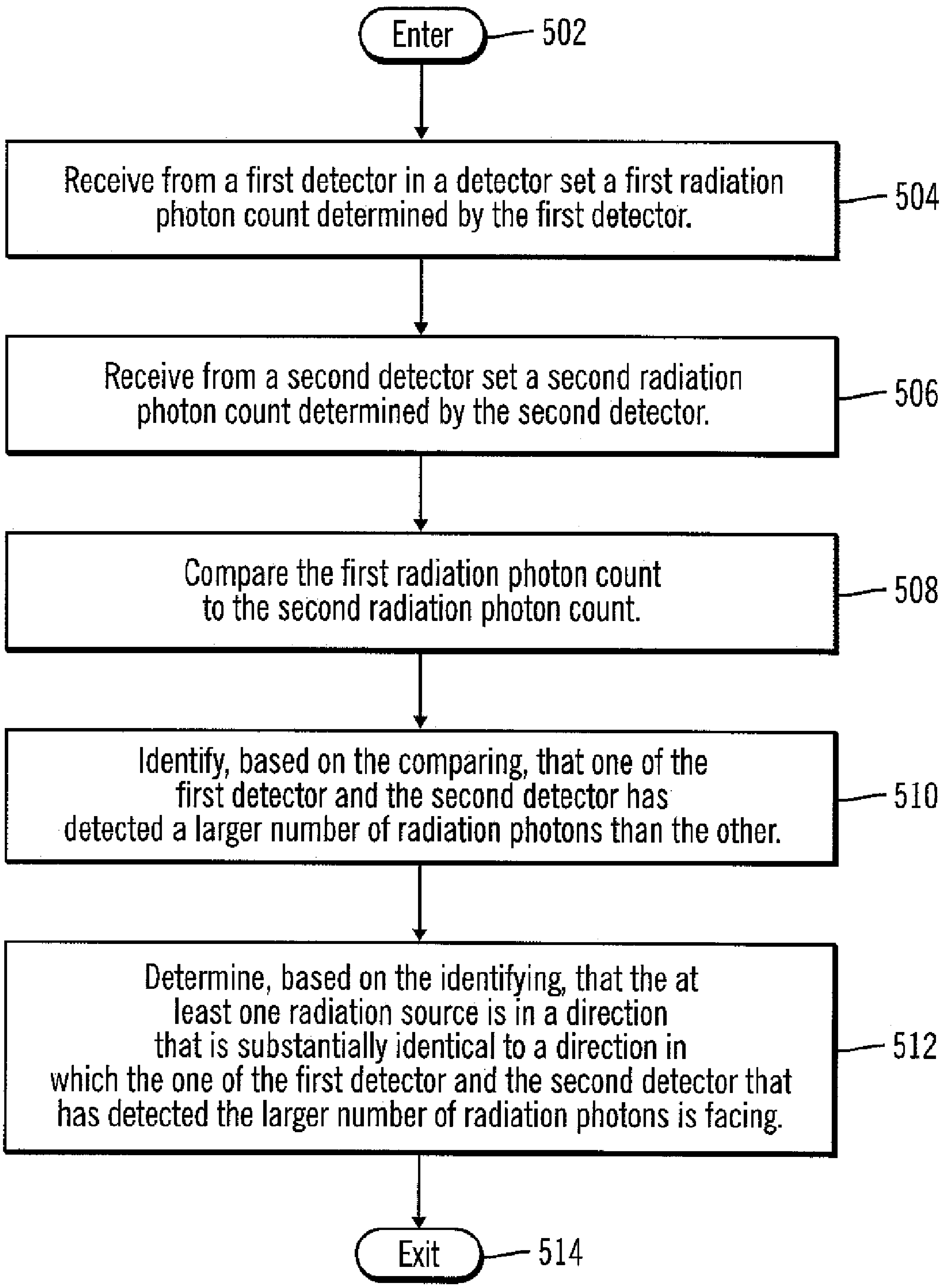

Enter
502
Receive from a first detector in a detector set a first radiation photon count determined by the first detector.
504
Receive from a second detector set a second radiation photon count determined by the second detector.
506
Compare the first radiation photon count to the second radiation photon count.
508
Identify, based on the comparing, that one of the first detector and the second detector has detected a larger number of radiation photons than the other.
510
Determine, based on the identifying, that the at least one radiation source is in a direction that is substantially identical to a direction in which the one of the first detector and the second detector that has detected the larger number of radiation photons is facing.
512
Exit
514

FIG. 5

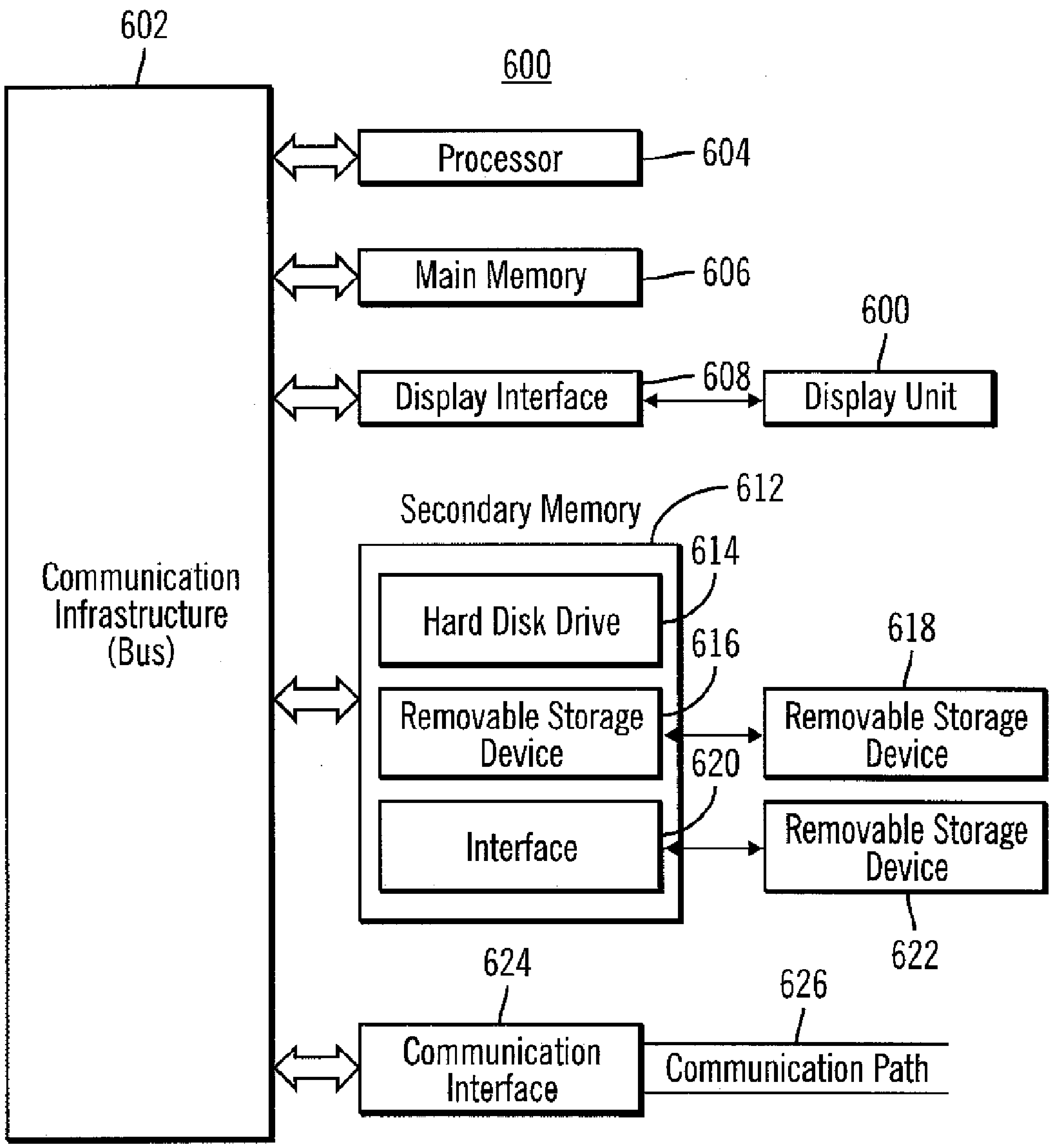

602
600
Processor
604
Main Memory
606
600
Display Interface
608
Display Unit
Secondary Memory
612
614
Communication Infrastructure (Bus)
Hard Disk Drive
616
618
Removable Storage Device
Removable Storage Device
620
Interface
Removable Storage Device
622
624
626
Communication Interface
Communication Path

FIG. 6

RADIATION DIRECTIONAL FINDER AND ISOTOPE IDENTIFICATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on and claims priority to co-pending provisional U.S. Patent Application No. 61/128,114, entitled "Radiation Directional Finder and Isotope Identification System", filed on May 19, 2008, by the same inventor, and to co-pending U.S. patent application Ser. No. 12/409,733, entitled "Mobile Radiation Threat Identification System", filed on Mar. 24, 2009, by the same inventor, which is based on and claims priority to previously co-pending, and now expired, provisional U.S. Patent Application No. 61/070,590, entitled "Marine and Vehicle Mobile Radiation Threat Identification System", filed on Mar. 24, 2008, by the same inventor, and this application is further based on and claims priority to co-pending provisional U.S. Patent Application No. 61/128,115, entitled "Mobile Frame Structure With Passive/Active Sensor Arrays For Non-Invasive Analysis For CBRNE Materials Present", filed on May 19, 2008, by the same inventor, and to co-pending provisional U.S. Patent Application No. 61/208,492, entitled "Method For Increased Gamma/Neutron Detector Performance", filed on Feb. 25, 2009, by the same inventor, and to co-pending provisional U.S. Patent Application No. 61/210,075, entitled "Method For Increased Gamma/Neutron Detector Performance", filed on Mar. 13, 2009, by the same inventor, and to co-pending provisional U.S. Patent Application No. 61/209,194, entitled "High Performance Neutron Detector With Near Zero Gamma Cross Talk", filed on Mar. 4, 2009, by the same inventor, co-pending provisional U.S. Patent Application No. 61/210,122, entitled "High Performance Neutron Detector With Near Zero Gamma Cross Talk, version 2", filed on Mar. 13, 2009, by the same inventor, and co-pending provisional U.S. Patent Application No. 61/210,234, entitled "High Performance Neutron Detector With Near Zero Gamma Cross Talk, version-3", filed on Mar. 16, 2009, by the same inventor; the entire collective teachings of which being incorporated herein by reference.

FIELD OF THE INVENTION

The present invention generally relates to the field of radiation detection, and more particularly relates identifying a direction of radiation emanation and identifying isotopes associated with the radiation.

BACKGROUND OF THE INVENTION

Radiation detection systems are currently being deployed throughout the world to help prevent catastrophic events. Some radiation detection systems utilize radiation directional detectors that try to identify the direction in which radiation is being emanated. Current radiation directional detectors use heavy shielding behind each detector to focus the detection in a specific direction. Other systems also deploy collimators to assist in directional detection. One type of radiation detector is a plastic scintillator, which has a low cost. Plastic scintillators can provide very large surface areas, which with optimal width is good for long distance detection. However, plastic scintillators do not have the ability to perform spectral analysis. Therefore, system based on plastic scintillators generally cannot identify the source of radiation, which can be naturally occurring radiation material (NORM).

Most current directional detector systems employ heavy metals for shielding that are in addition to the overall weight and cost. Another radiation detection method is to combine multiple detectors to define the vector of the photon. This method requires more than two detectors per direction to identify the photon vector. Another recent design uses four Cerium Doped Lanthanum Bromide (LaBr3:Ce) Scintillation detectors with high resolution capabilities to determine the vector of the radiation source. These specialized detectors are extremely expensive with crystals that cannot be grown to accommodate large surface area detectors. The Labr3:Ce scintillators have very strong identification capabilities, due to high resolution of Labr3:Ce detectors, but the high cost and limits in available detector crystal sizes makes them unpractical to use. Labr3:Ce scintillators have 180 degree symmetry. This means that Labr3:Ce scintillators cannot identify difference between a source in front of detector or with a same angle behind the detector.

The deficiencies of the current systems available do not address the needs of critical security applications. The current methods for creating directional radiation detectors are too costly, bulky or have heavy weight factors. In addition, the current radiation detection methods do not offer a combined stand-off detection, directional finder, position locator, radiation source movement tracking and isotope identification in a cost effective, light weight, and efficient approach that does not require highly specialized detector performance characteristics.

Therefore a need exists to overcome these problems as discussed above

SUMMARY OF THE INVENTION

In one embodiment, a method for determining a direction associated with gamma and/or neutron radiation emissions is disclosed. The method includes determining receiving from a first detector a first radiation photon count (e.g., gamma particle count and/or neutron particle count) determined by the first detector in a detector set. The first radiation photon count is associated with at least one radiation source. A second radiation photon count (e.g., gamma particle count and/or neutron particle count) determined by a second detector in the detector set is received from the second detector. The second radiation photon count is associated with the at least one radiation source. The first radiation photon count is compared to the second radiation photon count. One of the first detector and the second detector is identified to have detected a larger number of radiation photons than the other based on the comparing. The at least one radiation source is determined to be in a direction that is substantially identical to a direction in which the one of the first detector and the second detector that has detected the larger number of radiation photons is facing based on the identifying.

In another embodiment, a frame structure comprising at least a first portion and a second portion configured to receive an object therebetween, for determining a direction associated with gamma and/or neutron radiation emitting from the object is disclosed. The object may include, for example, a shipping container for containing cargo, a storage device, or any type of object that could be suspect for including a radiation source. The frame structure can comprise any type of frame structure that can be mechanically coupled to such an object. For example, and not for limitation, the frame structure may comprise any of a gantry crane, a spreader bar, a forklift, a straddle carrier, and generally any type of vehicle such as a truck, automobile, marine vessel, airplane, and the like, and any type of fixed frame structure, such as a portal that vehicles/containers pass through. The frame structure includes at least one set of radiation detectors. The at least one set of radiation detectors includes a first detector and at least a second detector. The first detector and the at least second detector are mechanically coupled together in a configuration such that each detector shields the other detector from detected radiation emissions. A body portion of the first detector is mechanically coupled to a body portion of the at least second detector so that the first detector and the at least second detector are adjacent to each other. A sensing portion of the first detector and a sensing portion of the at least second detector face opposite directions. The frame structure also includes at least one information processing system coupled to the at least one set of radiation detectors. The at least one information processing system is adapted to receive from a first detector a first radiation photon count determined by the first detector in a detector set. The first radiation photon count is associated with at least one radiation source. A second radiation photon count determined by a second detector in the detector set is received from the second detector. The second radiation photon count is associated with the at least one radiation source. The first radiation photon count is compared to the second radiation photon count. One of the first detector and the second detector is determined to have detected a larger number of radiation photons than the other based on the comparing of the first and second counts. The at least one radiation source is determined to be in a direction that is substantially identical to a direction in which the one of the first detector and the second detector that has detected the larger number of radiation photons is facing based on the identifying.

In yet another embodiment, a system determines a direction associated with gamma and/or neutron radiation emitting from the object. The system includes at least one structure and at lest one network. The structure includes at least a first portion and a second portion configured to receive an object therebetween, for determining a direction associated with gamma and/or neutron radiation emitting from the object. The frame structure includes at least one set of radiation detectors. The at least one set of radiation detectors includes a first detector and at least a second detector. The first detector and the at least second detector are mechanically coupled together in a configuration such that each detector shields the other detector from detected radiation emissions. A body portion of the first detector is mechanically coupled to a body portion of the at least second detector so that the first detector and the at least second detector are adjacent to each other. A sensing portion of the first detector and a sensing portion of the at least second detector face opposite directions. The system also includes at least one information processing system communicatively coupled to the network and the at least one set of radiation detectors. The at least one information processing system is adapted to receive from a first detector a first radiation photon count determined by the first detector in a detector set. The first radiation photon count is associated with at least one radiation source. A second radiation photon count determined by a second detector in the detector set is received from the second detector. The second radiation photon count is associated with the at least one radiation source. The first radiation photon count is compared to the second radiation photon count. One of the first detector and the second detector is identified to have detected a larger number of radiation photons than the other based on the comparing. The at least one radiation source is determined to be in a direction that is substantially identical to a direction in which the one of the first detector and the second detector that has detected the larger number of radiation photons is facing based on the identifying.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying figures where like reference numerals refer to identical or functionally similar elements throughout the separate views, and which together with the detailed description below are incorporated in and form part of the specification, serve to further illustrate various embodiments and to explain various principles and advantages all in accordance with the present invention.

FIG. **1** is a block diagram illustrating a general overview of an operating environment according to one embodiment of the present invention;

FIG. **2** is schematic of a radiation directional detection set according to one embodiment of the present invention;

FIGS. **3-4** show illustrative examples of various configurations for radiation directional detector sets according to one embodiment of the present invention;

FIG. **5** is an operational flow diagram illustrating one process of determining the direction from which radiation is emanating according to one embodiment of the present invention; and

FIG. **6** is a block diagram illustrating a detailed view of an information processing system, according to one embodiment of the present invention.

DETAILED DESCRIPTION

As required, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely examples of the invention, which can be embodied in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present invention in virtually any appropriately detailed structure. Further, the terms and phrases used herein are not intended to be limiting; but rather, to provide an understandable description of the invention.

The terms "a" or "an", as used herein, are defined as one or more than one. The term plurality, as used herein, is defined as two or more than two. The term another, as used herein, is defined as at least a second or more. The terms including and/or having, as used herein, are defined as comprising (i.e., open language). The term coupled, as used herein, is defined as connected, although not necessarily directly, and not necessarily mechanically.

General Operating Environment

According to one embodiment of the present invention as shown in FIG. **1** a general view of an operating environment **100** is illustrated. The operating environment **100** enables stand-off radiation detection, determination of the direction of the emanating radiation source, and isotope identification. As discussed in greater detail below, the operating environment **100** implements a plurality of radiation detectors that are coupled together in a back-to-back configuration to create a directional detector. With this type of configuration shielding material is not required, as each coupled detector acts as a shield for an opposing detector.

Two or more sets of back-to-back or "sandwiched" detectors are used to form a radiation directional finder and identifier ("RDFI"). By using two sets of back-to-back coupled detectors, with each set aligned at substantially 90 degrees to the other, the detection data from all of the detectors can be used to detect radiation at stand-off distances in a 360 degree view and determine the direction of the emanating radiation source. A stand-off distance is defined as at least 100 feet from the detectors to a potential threat, which in this example is a radiation source. RDFI's can be deployed on fixed or mobile platforms. The use of two or more fixed RDFI systems can be used to identify the position of the radiation source through triangulation. One or more mobile platforms can acquire data from two or more positions to identify the position of the radiation source through triangulation. Mobile and fixed platforms may be combined to provide the triangulation data. Note that each mobile RDFI system could include a GPS detector which can be used to identify a geographical location of the RDFI system detectors. This geographical location information can be combined with the triangulation information relative to the radiation source to accurately identify the position of the radiation source in a geographic region.

The operating environment **100** also enables the further collection of the RDFI spectral data that can be used for isotope identification of the radiation from the radiation source.

In particular, FIG. **1** shows one or more radiation detector sets **102**, **104** and one or more neutron detector sets **106**, **108** that are communicatively coupled to a first network **110**. The radiation detector sets **102**, **104**, in one embodiment, are gamma detector sets. In one embodiment, at least one of the radiation detector sets **102**, **104** and neutron detector sets **106**, **108** are directional detection sets ("DDS"). A DDS radiation set includes two detectors coupled to one another in a back-to-back configuration. The DDS radiation sets and their configuration are discussed in greater detail below.

Each of the detector sets **102**, **104**, **106**, **108** includes one or more detectors/sensors **103**, **105**. One or more of these detectors, in one embodiment, are shielded from electro-magnetic-interference ("EMI"), but this is not required. In one embodiment, the detectors **102**, **105** of detector set(s) are gamma radiation detectors and the sensors **103**, **105** in another detector set are neutron sensor devices. However, each of the detector sets **102**, **104**, **106**, **108**, **106**, **108** can include a combination of gamma and neutron sensing devices as well.

Examples of radiation detectors are cadmium zinc telluride detectors, sodium iodide detectors, and the like. Neutron detectors can be solid-state neutron detectors, which provide shock resistance. Also, to assist in the detection of radiation at stand-off distances, according to certain embodiments of the invention, the gamma detectors may be equipped with collimators and/or lenses that gather the radiological particles and focus these particles onto the detectors. Shock resistance detectors are suitable for verifying radiation from objects that can move and cause shock/vibration hazards to the sensors. Each detector set **102**, **104**, **106**, **108** is communicatively coupled to a sensor interface **112**, **114**, **116**, **118** either by a wired and/or wireless communication link. The sensor interfaces **112**, **114**, **116**, **118** communicatively couple the detector sets **102**, **104**, **106**, **108** to the first network **110** thereby creating a distributed sensor network.

The first network **110** includes wired and/or wireless technologies and the sensor interface units **112**, **114**, **116**, **118** are communicatively coupled to the first network **110** either wirelessly and/or via wired mechanisms. In one embodiment, the sensor interfaces **112**, **114**, **116**, **118** assign a unique IP address to each of the detectors **103**, **105** within the detector sets **102**, **104**, **106**, **108**. The sensor interfaces **112**, **114**, **116**, **118**, in one embodiment, are sensor integration units ("SIU") that provide the calibration, automated gain control, calibration verification, remote diagnostics, and connectivity to the processor for spectral analysis of the sensor data. SIUs are

discussed in greater detail in U.S. Pat. No. 7,269,527 entitled "System integration module for CBRNE sensors", filed on Jan. 17, 2007, which is commonly owned and is hereby incorporated by reference in its entirety. It should be noted that although FIG. **1** shows each of the detector sets **102**, **104**, **106**, **108** coupled to a separate sensor interface **112**, **114**, **116**, **118** a single sensor interface can be coupled to all of the detector sets **102**, **104**, **106**, **108**.

One or more micro-neutron pulse devices **120** are also optionally included within the operating environment **100** and are communicatively coupled to the first network **110**. A micro-neutron pulse device **120** is an active analysis device that emits neutron pulses and whereby gamma feedback identifies shielded radiological materials such as highly enriched uranium, explosives, illicit drugs, or other materials.

The operating environment **100** also includes an information processing system **122** communicatively coupled to the first network **110** via one or more wired and/or wireless communication links. The information processing system **122** includes a data collection manager **124** and is communicatively coupled to one or more data storage units **126**. The one or more storage units **126** can reside within the information processing system **122** and/or outside of the system **122**, as shown in FIG. **1**. The data collection manager **124** manages the collection and/or retrieval of data **128** generated by the detectors/sensors **103**, **105** within the detector sets **102**, **104**, **106**, **108** and optionally the micro-neutron pulse device(s) **120**.

The data **128** generated by each of the detectors **103**, **105**, in one embodiment, is detailed spectral data from each sensor device that has detected radiation such as gamma radiation and/or neutron radiation. The data collection manager **124**, in one embodiment, stores the data **128** received/retrieved from the detector sets **102**, **104**, **106**, **108** and/or the neutron pulse device **120** in one or more data storage devices **126**. A data storage device **126** can be a single hard-drive, two or more coupled hard-drives, solid state memory devices, and/or optical media such as (but not limited to) compact discs and digital video discs, and the like. It should be noted that this list of storage devices is not exhaustive and any type of storage device can be used. It should also be noted that information processing system **122** including the data collection manager **124** is modular in design and can be used specifically for radiation detection and identification and/or for data collection for explosives and special materials detection and identification.

The operating environment **100**, in one embodiment, also includes an information processing system **130** communicatively to the at least a second network **131** via one or more wireless and/or wired communication technologies. The information processing system **130**, in one embodiment, includes a data analysis and monitoring manager **132** that analyzes and monitors the data **128** retrieved/received from the detector sets **102**, **104**, **106**, **108** and optionally the micro-neutron pulse device **120**. The data analysis and monitoring manager **132**, in one embodiment, includes a radiation directional analyzer **134**, a multi-channel analyzer **136**, and a spectral analyzer **138**. The data analysis and monitoring manager **132** and each of these aforementioned components **134**, **136**, **138** are discussed in greater detail below.

In one embodiment, a user interface **140**, a manifest database **142**, and a materials database **144** are communicatively coupled to the information processing system **130** either directly or via a network (e.g. a second network **131**). The user interface **140**, in one embodiment, comprises one or more displays, input devices, output devices, and/or the like, that allows a user to monitor and/or interact with the information processing system **130**. The data and analysis functionality of the information processing system **130**, which is discussed in greater detail below, can either be automated and/or supplemented with human interaction. The user interface(s) **140** enables this human interaction.

The manifest database **142** includes a plurality of manifests **146** associated with shipping cargo, which can be cargo on a water vessel, a ground vessel (e.g., cars, trucks, and/or trains), and/or an air transportation vessel. A manifest **146** includes a detailed description of the contents of each container or cargo that is to be examined by the detector sets **102**, **104**, **106**, **108** and/or the neutron pulse device(s) **120**. The manifests **146** are used by the information processing system **130** to determine whether the possible materials, goods, and/or products within the container package, car, truck, or the like match the expected authorized materials, goods, and/or products, described in the manifest **146** for the particular entity under examination. The use of a manifest **146** during examination of an entity is discussed in greater detail below.

The materials database **144** includes materials information **148** such as chemical material information, biological material information, radioactive material information, nuclear material information, and/or explosive material information. Also, the materials information **148** can include isotope information for known isotopes. For example, isotope information can include spectral images, histograms, energy levels, and/or the like associated with known isotopes. The materials information **148**, in one embodiment, is used by the data analysis and monitoring manager **132** to determine whether any hazardous materials are within an entity that is being examined. This identification/detection process is discussed in greater detail below.

It should be noted that although the manifest database **142** and the materials database **144** are shown in FIG. **1** as being separate from the information processing system **130**, one or more of these databases **142**, **144** can reside within the information processing system **132** as well. Furthermore, the components of the information processing system **122** and the information processing system **130** can be implemented within a single information processing system as compared to multiple systems as shown in FIG. **1**.

The operating environment **100**, in one embodiment, also includes a remote monitoring information processing system **150** communicatively coupled to the second network **131**. A user interface **152**, which can be one or more displays, input devices, output devices and/or the like that allows a user to monitor and/or interact with the remote system **150**. The remote monitoring system **150** includes a computer, memory, and storage and enables a user to remotely monitor and/or manage the data analysis and monitoring process being performed at the information processing system **130**. Furthermore, the remote monitoring system **152** can be a device such as a wireless communication device, portable computer, desktop, and/or the like that receives notifications from the information processing system **130** regarding the data analysis and monitoring process.

It should be noted that the first and second networks **110**, **131** can include any number of local area networks and/or wide area networks. It should be noted that even though FIG. **1** shows two networks **110**, **131**, a single network can be implemented or additional networks can be added. It should also be noted that the operating environment **100** can be fixed environment and/or a mobile environment. For example, the detector sets **102**, **104**, **106**, **108** can be disposed on a cargo crane (e.g. on a spreader bar), on a structure that cargo containers pass under/over, on an automobile, on a flatbed of a truck, on a boat, on a cargo mover such as a forklift, or the like. The data collection system **124** and the data analyzer and monitor **132** can be disposed on/at these locations as well or at remote locations.

DDS Detector Sets

FIG. **2** shows a more detailed view of a DDS detector set **200**, as discussed above. In particular, FIG. **2** shows two detector sets **202**, **204** coupled together to form a 360 degree DDS detector set **200**. In one embodiment, a DDS detector set **202** includes a first sensor **206** and a second sensor **208**. As discussed above, these sensors **206**, **208** can be radiation sensors such as gamma ray sensors and/or neutron detectors. Each sensor **206**, **208** includes a first end **210**, **212**, a second end **214**, **216**, and a body **218**, **220**, **221**, **223** situated between the first end **210**, **212** and the second end **214**, **216**.

A first portion **222** of the first sensor body **218** is coupled to a first portion **224** of the second sensor body **220** creating a back-to-back configuration as shown in FIG. **2**. In other words, the first sensor body **218** is coupled to the first portion **224** of the second sensor body **220** so that the body portions **218**, **220** are adjacent to each other. In one embodiment, the first sensor set **202** and the second sensor set **204** are situated with perpendicular to each other thereby creating substantially 90 degree angles between the detector sets **202**, **204**. It should be noted that FIG. **2** shows only one configuration applicable to the present invention and other configurations apply as well.

One advantage of coupling detectors **206**, **208** within a detector set **202** so that the body portions **218**, **220** are adjacent to each other is that this configuration provides mutual shielding between the two detectors **252**, **254**. Furthermore, this configuration creates an efficient directional detector which is more cost effective, weighs less, and is more compact than conventional methods. Also, this configuration enables ordinary detectors such as plastic scintillators, sodium iodide detectors, or any other detector without special characteristics such as the high energy resolution of Cerium Doped Lanthanum Bromide (LaBr3:Ce) scintillators to be used within the DDS detector sets.

FIGS. **3** and **4** show illustrative examples of various DDS detector configurations. FIG. **3** shows a two component detector set **302** configured in a similar fashion as the detector set **202** discussed above with respect to FIG. **2**. A radiation source **304** emits radiation denoted by lines **306**, **308**, **310**, **312**. A first detector **314** that is facing or is the closest to the radiation source **304** receives/senses a majority of the radiation emitted from the radiation source **304**. The second detector **316**, which is facing away from the radiation source **304** in this example, receives/senses a lesser amount of the radiation emitted from the radiation source **304**. In other words, the partner detector, i.e., the first detector **314**, of the second detector **316** shields the second detector **316** from the majority of the radiation signals. In one embodiment, the detectors **314**, **316** detect gamma and/or neutron photons emitted by the radiation source **304** and maintain a gamma and/or neutron photon count of the photons detected.

In the example of FIG. **3**, a portion **306** of the radiation emitted by the source **304** has been reflected off an entity **318** such as a structure, water, a vehicle, or the like, and then received by the second detector **316**. The amount of reflected radiation **320** received/sensed by the second detector **316** would generally be less than the radiation **308**, **310**, **312** directly received/sensed by the first detector **314** from the source **304**. This relative difference in radiation levels in the same energy fields detected by the detectors **314**, **316** is used by the analysis and monitoring manager **132** to determine the direction of radiation emission and/or a direction to where the radiation source **304** is located.

FIG. **4** shows another example where two detector sets **402**, **404** are coupled together as discussed above with respect to FIG. **2** for providing 360 degree directional detection. The DDS modules **402**, **404** are positioned 90 degrees (e.g., situated in a substantially perpendicular configuration with respect to each other) apart creating a radiation directional finder ("RDF"). This configuration enables a two-dimensional 360 degree view for determining the specific direction that a radiation source **406** is emitting radiation energy from. Analysis of data from both DDS sets **402**, **404**, provides angular information of the direction of the radiation energy from the radiation source. A three-dimensional 360 degree view can be created by adding a third detector set (not shown) on the z-axis. For example, the first detector set **402** is disposed on the x-axis **408**, the second detector set **404** is disposed on the y-axis **410**, and a third detector set (not shown) is disposed on the z-axis **412**.

The DDS detector sets **402**, **404** enable the system **100** to determine a direction to the source of radiation without ambiguity. In one embodiment, the detectors **414**, **416**, **418**, **420** are configured to absorb gamma rays by via Sodium Iodide (NaI) crystals within each detector/sensor. Also, the detectors **414**, **416**, **418**, **420** can be configured to absorb neutrons as well. When two detectors **414**, **416** (**314**, **316**) are situated next to each other, the detector closest to the radiation source **406** absorbs a larger portion of the gamma rays, so the second detector has less number of gammas/neutrons hitting it. By comparing the number of counts at each detector **414**, **416** in two back-to-back configured detectors, the data analysis and monitoring manager **132** determines in which half of a circle a source is located. The cross-section of the area is determined by two orthogonal "sandwiched" detectors. This narrows down the area to a quarter of a circle (90 degrees). For example, FIG. **4** shows a first quarter **422**, a second quarter, **424**, a third quarter **426**, and a fourth quarter **428**. To determine the direction of the source **406**, the ratio in counts between two orthogonal back-to-back is combined together and analyzed.

As discussed above, the detector sets can be disposed in a mobile environment. In one embodiment, gamma detectors sets can be combined with neutron detectors sets in a distributed sensor network within a vehicle or marine vessel. In this embodiment, the gamma and neutron sensors are deployed on both sides of the vessel in multiple positions on each side. In a fixed environment such as a portal (e.g., a frame structure that vehicles/containers pass through, the gamma and neutron sensors are deployed on both sides of the vessel in multiple positions on each side to provide adequate coverage of the full vehicle/container lengths. The detectors/sensors can be configured as a horizontal portal across the centerline of the container to minimize the number of sensors required and to optimize the data acquisition times.

The spectral data **128** collected by each of the sensors **103**, **105** within the detector arrays **102**, **104**, **106**, **108** is used by the radiation directional analyzer **136** to determine a direction from which radiation is being emitted, detect radiation itself, and to identify materials emitting the radiation. For example, the radiation directional analyzer determines the direction of the radiation source, by combining together the energy ratio between two orthogonal back-to-back detectors and performing an analysis operation.

With respect to examining an entity to identify hazardous materials, as the detector sets **102**, **104**, **106**, **108** scan the entity, each of the gamma and/or neutrons sensors can generate signals indicative of any gamma and/or neutron radiation detected. As discussed above, this sensor data **128** is collected by the data collection manager **132** and stored within one or more data storage units **126**. The data analysis and monitoring manager **132** then analyzes the data **128** to determine if any hazardous materials have been detected.

For example, the data analysis and monitoring manager **132** includes a multi-channel analyzer ("MCA") **136** comprising one or more devices a device composed of multiple single channel analyzers ("SCA"). In one embodiment, the MCA **136**, uses analog to digital converters combined with computer memory that is equivalent to thousands of SCAs and counters and is dramatically more powerful and cost efficient than individual SCAs. The SCA interrogates analog signals received from the individual radiation detectors **103**, **105**, and determines whether the specific energy range of the received signal is equal to the range identified by the single channel. If the energy received is within the SCA an SCA counter is updated. Over time, the SCA counts are accumulated. At a given time interval, a multi-channel analyzer **136** includes a number of SCA counts, which result in the creation of a histogram **154**.

The histogram **154**, according to one embodiment, represents the spectral image of the radiation that is present within the entity being examined. In other words, the histogram **154** is a fingerprint of the entity being examined. The histogram **154** can represent a portion of the entity or the entire entity. In one embodiment, a single histogram **154** can be created based on information received from all of the detector arrays **102**, **104**, **106**, **108**. In another embodiment, a single histogram **154** can be created from the combination of one or more histograms associated with one or more detectors **103**, **105** in the detector arrays **102**, **104**, **106**, **108**. In yet another embodiment, a histogram **154** can be created for each sensor **103**, **105** within the sensor arrays **102**, **104**. A more detailed discussion on histograms is given in U.S. Pat. No. 7,142,109 entitled "Container Verification System For Non-Invasive Detection Of Contents", filed on Feb. 27, 2006; and U.S. Pre-Grant Publication 2008/0048872 entitled, "Multi-Stage System For Verification Of Container Contents", filed on Oct. 31, 2007; and which collective teachings thereof are hereby incorporated by reference in their entirety.

In the present example, the histogram **154** is used by the spectral analyzer **138** to identify isotopes that are present in materials residing within the entity under examination. One of the functions performed by the data and analysis manager **132** is spectral analysis, performed by the spectral analyzer **138**, to identify the one or more isotopes, explosives or special materials residing within the entity under examination. With respect to radiation detection, the spectral analyzer **138** compares one or more spectral images (e.g., histograms **154**) of the radiation that has been detected within the entity to known isotopes that are represented by one or more spectral images stored **148** in the materials database **144**. By capturing multiple variations of spectral data for each isotope there are numerous images that can be compared to one or more spectral images of the detected radiation present.

The materials database **144** contains material information **148** such as one or more spectral images **148** of each isotope to be identified. These multiple spectral images represent various levels of acquisition of spectral radiation data so isotopes can be compared and identified using various amounts of spectral data available from the one or more sensors. Whether there are small amounts or large amounts of data acquired from the sensor, the spectral analyzer **138** compares the acquired radiation data from the detector **103**, **105** to one or more spectral images **148** for each isotope to be identified. This significantly enhances the reliability and efficiency of matching acquired spectral image data from the sensor to spectral image data of each possible isotope to be identified.

Once one or more possible isotopes are determined to be present in the radiation detected by the detector(s) **103**, **105**, the data analysis and monitoring manager **132** compares the isotope mix against possible materials, goods, and/or products that may be present in the entity under examination. The manifest database **142** includes a detailed description **146** of the contents of each entity **210** that is to be examined. The manifest **146** can be referred to by the data analysis and monitoring manager **132** to determine whether the possible materials, goods, and/or products, contained in the entity **210** match the expected authorized materials, goods, and/or products, described in the manifest **146** for the particular container under examination. This matching process, according to one embodiment of the present invention, is significantly more efficient and reliable than any container contents monitoring process has been in the past.

It should be noted that the spectral analyzer **138** is able to utilize various methods to provide multi-confirmation of the isotopes identified. Should more than one isotope be present, the spectral analyzer **138** identifies the ratio of each isotope present. Examples of methods that can be used for spectral analysis, such as that discussed above, include: 1) a margin setting method as described in U.S. Pat. No. 6,847,731 entitled "Method And System For Improving Pattern Recognition System Performance", filed Aug. 7, 2000, which is hereby incorporated by reference in its entirety; and 2) a LINSCAN method (a linear analysis of spectra method) as described in U.S. Provisional patent application Ser. No. 11/624,067, filed on Jan. 17, 2006, by inventor David L. Frank, and entitled "Method For Determination Of Constituents Present From Radiation Spectra And, If Available, Neutron And Alpha Occurrences"; the collective entire teachings of which being herein incorporated by reference.

With respect to analysis of collected data pertaining to explosives and/or special materials, the spectral analyzer **138** compares identified possible explosives and/or special materials to the manifest **148** by converting the stored manifest data **148** relating to the entity under examination to expected explosives and/or radiological materials and then by comparing the identified possible explosives and/or special materials with the expected explosives and/or radiological materials. If the system determines that there is no match to the manifest **148** for the entity then the identified possible explosives and/or special materials are unauthorized. The system can then provide information to system supervisory personnel to alert them to the alarm condition and to take appropriate action. For example, the user interface **140**, **152** can present to a user a representation of the collected received returning signals, or the identified possible explosives and/or special materials in the entity under examination, or any system identified unauthorized explosives and/or special materials contained within the entity under examination, or any combination thereof.

A more detailed discussion on spectral analysis is given in U.S. Pat. No. 7,142,109 entitled "Container Verification System for Non-Invasive Detection of Contents", filed on Feb. 27, 2006; and U.S. Pre-Grant Publication 2008/0048872 entitled, "Multi-Stage System For Verification Of Container Contents", filed on Oct. 31, 2007; and which collective teachings thereof being hereby incorporated by reference in their entirety.

In addition to gamma and neutron sensors, neutron pulse devices **120** can also be deployed on a structure such as a vehicle, shuttle carrier, or the like as discussed above. The neutron pulse devices **120** include coincident counting capabilities. The gamma detectors within the neutron pulse device are used to identify chemical and explosives materials from the gamma response to the neutron pulse. The neutron detectors are used to identify shielded nuclear materials from the response.

The micro-neutron pulse device(s) **120** creates an active detection system that is deployed on structure that enable the identification of chemical, nuclear and explosives materials based on the response from the neutron pulse. These non-intrusive inspection systems can interrogate entities for the detection of shielded nuclear materials while maintaining a high hourly throughput in ports of entry, ports of departure, borders and other checkpoints. A more detailed discussion on using micro-neutron pulse devices is provided in the provisional U.S. Patent Application No. 61/128,115, entitled "Mobile Frame Structure With Passive/Active Sensor Arrays For Non-Invasive Analysis For CBRNE Materials Present", filed on May 19, 2008, by the same inventor as the present application, and which is hereby incorporated by reference in its entirety.

As can be seen form the above discussion, a plurality of radiation detectors that are coupled together in a back-to-back configuration are used to create a directional detector. These directional detectors do not require any addition of shielding material, as each back-to-back coupled detector acts as a shield for an opposing detector. By using two sets of back-to-back coupled detectors, with each set aligned at substantially 90 degrees to the other, the detection data from all of the detectors can be used to detect radiation at stand-off distances (such as at least 100 feet or more) in a 360-degree view and to determine the direction of the radiation source that is emitting the radiation energy being detected.

Example of a Process for Radiation Direction Identification

FIG. **5** is an operational flow diagram illustrating one process of determining the direction from which radiation is emanating. The operational flow diagram starts at step **502** and flows directly into step **504**. The data analysis and monitoring manager **135**, at step **504**, receives from a first detector **103** in a detector set **102**, a first radiation photon count (e.g., gamma particle count and/or neutron particle count) determined by the first detector **103**. The first radiation photon count is associated with at least one radiation source **308**. The manager **132**, at step **506**, receives from a second detector **105** in the detector set **102**, a second radiation photon count (e.g., gamma particle count and/or neutron particle count) determined by the second detector **103**. The second radiation photon count is associated with the at least one radiation source **308**.

The manager **132**, at step **508**, compares the first radiation photon count to the second radiation photon count. The manager **132**, at step **510**, identifies, based on the comparing, that one of the first detector **103** and the second detector **105** has detected a larger number of radiation photons than the other. The manager **132**, at step **512**, determines, based on the identifying, that the at least one radiation source is in a direction that is substantially identical to a direction in which the one of the first detector and the second detector that has detected the larger number of radiation photons is facing. The control flow then exits at step **514**.

Information Processing System

FIG. **6** is a high level block diagram illustrating a more detailed view of a computing system **600** such as the information processing system **130** useful for implementing the data and analysis manager **132** according to the various embodiments of the present invention. The computing system **600** is based upon a suitably configured processing system adapted to implement an exemplary embodiment of the present invention. For example, a personal computer, workstation, or the like, may be used.

In one embodiment of the present invention, the computing system **600** includes one or more processors, such as processor **604**. The processor **604** is connected to a communication infrastructure **602** (e.g., a communications bus, crossover bar, or network). Various software embodiments are described in terms of this exemplary computer system. After reading this description, it becomes apparent to a person of ordinary skill in the relevant art(s) how to implement the invention using other computer systems and/or computer architectures.

The computing system **600** can include a display interface **608** that forwards graphics, text, and other data from the communication infrastructure **602** (or from a frame buffer) for display on the display unit **610**. The computing system **600** also includes a main memory **606**, preferably random access memory (RAM), and may also include a secondary memory **612** as well as various caches and auxiliary memory as are normally found in computer systems. The secondary memory **612** may include, for example, a hard disk drive **614** and/or a removable storage drive **616**, representing a floppy disk drive, a magnetic tape drive, an optical disk drive, and the like. The removable storage drive **616** reads from and/or writes to a removable storage unit **618** in a manner well known to those having ordinary skill in the art.

Removable storage unit **618**, represents a floppy disk, a compact disc, magnetic tape, optical disk, etc. which is read by and written to by removable storage drive **616**. As are appreciated, the removable storage unit **618** includes a computer readable medium having stored therein computer software and/or data. The computer readable medium may include non-volatile memory, such as ROM, Flash memory, Disk drive memory, CD-ROM, and other permanent storage. Additionally, a computer medium may include, for example, volatile storage such as RAM, buffers, cache memory, and network circuits. Furthermore, the computer readable medium may comprise computer readable information in a transitory state medium such as a network link and/or a network interface, including a wired network or a wireless network that allow a computer to read such computer-readable information.

In alternative embodiments, the secondary memory **612** may include other similar means for allowing computer programs or other instructions to be loaded into the computing system **600**. Such means may include, for example, a removable storage unit **622** and an interface **620**. Examples of such may include a program cartridge and cartridge interface (such as that found in video game devices), a removable memory chip (such as an EPROM, or PROM) and associated socket, and other removable storage units **622** and interfaces **620** which allow software and data to be transferred from the removable storage unit **622** to the computing system **600**.

The computing system **600**, in this example, includes a communications interface **624** that acts as an input and output and allows software and data to be transferred between the computing system **600** and external devices or access points via a communications path **626**. Examples of communications interface **624** may include a modem, a network interface (such as an Ethernet card), a communications port, a PCM-CIA slot and card, etc. Software and data transferred via communications interface **626** are in the form of signals which may be, for example, electronic, electromagnetic, optical, or other signals capable of being received by communications interface **624**. The signals are provided to communications interface **624** via a communications path (i.e., channel) **626**. The channel **626** carries signals and may be

implemented using wire or cable, fiber optics, a phone line, a cellular phone link, an RF link, and/or other communications channels.

In this document, the terms "computer program medium," "computer usable medium," "computer readable medium", "computer readable storage product", and "computer program storage product" are used to generally refer to media such as main memory **606** and secondary memory **612**, removable storage drive **616**, and a hard disk installed in hard disk drive **614**. The computer program products are means for providing software to the computer system. The computer readable medium allows the computer system to read data, instructions, messages or message packets, and other computer readable information from the computer readable medium.

Computer programs (also called computer control logic) are stored in main memory **606** and/or secondary memory **612**. Computer programs may also be received via communications interface **624**. Such computer programs, when executed, enable the computer system to perform the features of the various embodiments of the present invention as discussed herein. In particular, the computer programs, when executed, enable the processor **604** to perform the features of the computer system.

NON-LIMITING EXAMPLES

Although specific embodiments of the invention have been disclosed, those having ordinary skill in the art will understand that changes can be made to the specific embodiments without departing from the spirit and scope of the invention. The scope of the invention is not to be restricted, therefore, to the specific embodiments, and it is intended that the appended claims cover any and all such applications, modifications, and embodiments within the scope of the present invention.

What is claimed is:

1. A method for determining a direction associated with gamma and/or neutron radiation emissions from a radiation source at stand-off distances, the method comprising:

receiving from a first detector in a detector set, a first radiation photon count associated with the first detector, wherein the first radiation photon count is associated with at least one radiation source located at a stand-off distance from the first detector;

receiving from a second detector in the detector set, a second radiation photon count associated with the second detector, wherein the second radiation photon count is associated with the at least one radiation source which is located at a stand-off distance from the second detector;

comparing the first radiation photon count to the second radiation photon count;

identifying, based on the comparing, that one of the first detector and the second detector has detected a larger number of radiation photons than the other; and

determining, based on the identifying, that the at least one radiation source is in a direction that is substantially identical to a direction in which the one of the first detector and the second detector that has detected the larger number of radiation photons is facing.

2. The method of claim **1**, wherein the first detector and the second detector are coupled together in a configuration such that each detector shields the other detector from detected radiation emissions.

3. The method of claim **2**, wherein the configuration includes:

a body portion of the first detector being mechanically coupled to a body portion of the second detector so that the first detector and the second detector are adjacent to each other, and wherein a sensing portion of the first detector and a sensing portion of the second detector face opposite directions.

4. The method of claim **1**, wherein the first and second radiation photon count comprise a gamma particle radiation photon count.

5. The method of claim **1**, wherein the first and second radiation photon count comprise a neutron particle radiation photon count.

6. The method of claim **1**, further comprising:

receiving from a third detector in at least one additional detector set, a third radiation photon count associated with the third detector, wherein the third radiation photon count being associated with the at least one radiation source which is located at a stand-off distance from the third detector; and

receiving from at least a fourth detector in the at least one additional detector set, at least a fourth radiation photon count associated with the at least fourth radiation detector, wherein the at least fourth radiation photon count is associated with the at least one radiation source which is located at a stand-off distance from the fourth detector.

7. The method of claim **6**, wherein the third detector and the at least fourth detector are coupled together in a configuration such that each detector shields the other detector from detected radiation emissions.

8. The method of claim **7**, wherein the configuration includes:

a body portion of the third detector being mechanically coupled to a body portion of the at least fourth detector so that the third detector and the at least fourth detector are adjacent to each other, and wherein a sensing portion of the third detector and a sensing portion of the at least fourth detector face opposite directions.

9. The method of claim **6**, wherein the detector set and the at least one additional detector set being situated with respect to each other in a configuration creating

a first quadrant between a first portion of the first detector and a first portion of the third detector,

a second quadrant between a second portion of the first detector and a first portion of the fourth detector,

a third quadrant between a first portion of the second detector and a second portion of the fourth detector, and

a fourth quadrant between a second portion of the second detector and a second portion of the third detector.

10. The method of claim **9**, wherein the first portion of the first detector and the first portion of the third detector are situated substantially perpendicular with respect to each other, and

wherein the second portion of the first detector and the first portion of the fourth detector are situated substantially perpendicular with respect to each other, and

wherein the first portion of the second detector and the second portion of the fourth detector are situated substantially perpendicular with respect to each other, and

wherein the second portion of the second detector and the second portion of the third detector are situated substantially perpendicular with respect to each other.

11. The method of claim **9**, further comprising:

comparing the first radiation photon count to the second radiation photon count, and comparing the third photon radiation count to the at least fourth radiation photon count;

identifying, based on the comparing, which of the first and second detectors comprises the largest radiation photon count, and which of the third and at least fourth detectors comprises the largest radiation photon count;

determining, based on the identifying, one of the first, second, third, and fourth quadrants that corresponds to the two detectors that have been identified; and

determining that the at least one radiation source is located in a direction associated with the quadrant that has been determined.

12. A radiation direction finder system, for determining a direction associated with gamma and/or neutron radiation emitted from an object, the system comprising:

at least one frame structure comprising at least a first portion and a second portion configured to be located relative to an object;

at least one set of radiation detectors mechanically coupled to the at least one frame structure, wherein the at least one set of radiation detectors includes a first detector and at least a second detector, wherein the first detector and the at least second detector are mechanically coupled together in a configuration such that each detector shields the other detector from detected radiation emissions, and wherein a body portion of the first detector is mechanically coupled to a body portion of the at least second detector so that the first detector and the at least second detector are adjacent to each other, and wherein a sensing portion of the first detector and a sensing portion of the at least second detector face opposite directions; and

at least one information processing system coupled to the at least one set of radiation detectors, wherein the at least one information processing system is adapted to:

receive from a first detector in a detector set, a first radiation photon count determined by the first detector, wherein the first radiation photon count is associated with at least one radiation source associated with an object;

receive from a second detector in the detector set, a second radiation photon count determined by the second detector, wherein the second radiation photon count is associated with the at least one radiation source associated with the object;

compare the first radiation photon count to the second radiation photon count;

identify, based on the first radiation photon count being compared to the second radiation photon count, that one of the first detector and the second detector has detected a larger number of radiation photons than the other; and

determine, based on identifying that one of the first detector and the second detector has detected a larger number of radiation photons than the other, that the at least one radiation source is in a direction that is substantially identical to a direction in which the one of the first detector and the second detector that has detected the larger number of radiation photons is facing.

13. The system of claim **12**, wherein the first detector and the at least second detector comprise one of a gamma radiation sensor and a neutron radiation sensor.

14. The system of claim **12**, further comprising:

at least one additional set of radiation detectors being situated in a perpendicular configuration with respect to the at least one set of radiation detectors, wherein the at least one additional set of radiation detectors includes a third detector and at least a fourth detector, wherein the third detector and the at least fourth detector are mechanically coupled together in a configuration such that each detector shields the other detector from detected radiation emissions, and wherein a body portion of the third detector is mechanically coupled to a body portion of the at least fourth detector so that the third detector and the at least second fourth are adjacent to each other, and wherein a sensing portion of the third detector and a sensing portion of the at least fourth detector face opposite directions.

15. The system of claim **14**, wherein the information processing system is further adapted to:

receive from the third detector, a third radiation photon count determined by the third detector, wherein the third radiation photon count is associated with the at least one radiation source;

receive from the at least fourth detector, at least a fourth radiation photon count determined by the at least fourth detector, wherein the at least fourth radiation photon count is associated with the at least one radiation source;

compare the first radiation photon count to the second radiation photon count, and compare the third photon radiation count to the at least fourth radiation photon count;

identify, based on the comparing, which of the first and second detectors comprises the largest radiation photon count, and which of the third and at least fourth detectors comprises the largest radiation photon count;

determining, based on the identifying, one of the first, second, third, and fourth quadrants that corresponds to the two detectors that have been identified; and

determining that the at least one radiation source is located in a direction associated with the quadrant that has been determined.

16. The system of claim **12**, wherein the first and second first radiation photon count is one of a gamma radiation photon count and a neutron radiation photon count.

17. A system for determining a direction associated with gamma and/or neutron radiation emitting from an object, the system comprising:

at least one vehicle;

at least one set of radiation detectors mechanically coupled to the at least one vehicle, wherein the at least one set of radiation detectors includes a first detector and at least a second detector, wherein the first detector and the at least second detector are mechanically coupled together in a configuration such that each detector shields the other detector from detected radiation emissions, and wherein a body portion of the first detector is mechanically coupled to a body portion of the at least second detector so that the first detector and the at least second detector are adjacent to each other, and wherein a sensing portion of the first detector and a sensing portion of the at least second detector face opposite directions;

at least one network; and

at least one information processing system communicatively coupled to the at least one network and the at least one set of radiation detectors, wherein the at least one information processing system is adapted to:

receive from a first detector in a detector set, a first radiation photon count associated with the first detector, wherein the first radiation photon count is associated with at least one radiation source;

receive from a second detector in the detector set, a second radiation photon count determined by the second detector, wherein the second radiation photon count is associated with the at least one radiation source;

compare the first radiation photon count to the second radiation photon count;

determining, based at least on the first radiation photon count being compared to the second radiation photon count, that the at least one radiation source is in a direction in which the one of the first detector and the second detector is substantially facing.

18. The system of claim **17**, wherein the first detector and the at least second detector comprise at least one of a gamma radiation sensor and a neutron radiation sensor.

19. The system of claim **17**, further comprising:

at least one additional set of radiation detectors mechanically coupled to the at least one vehicle and situated in a substantially perpendicular configuration with respect to the at least one set of radiation detectors, wherein the at least one additional set of radiation detectors includes a third detector and at least a fourth detector, wherein the third detector and the at least fourth detector are mechanically coupled together in a configuration such that each detector shields the other detector from detected radiation emissions, and wherein a body portion of the third detector is mechanically coupled to a body portion of the at least fourth detector so that the third detector and the at least second fourth are adjacent to each other, and wherein a sensing portion of the third detector and a sensing portion of the at least fourth detector face opposite directions.

20. The system of claim **19**, wherein the information processing system is further adapted to:

receive from the third detector, a third radiation photon count determined by the third detector, wherein the third radiation photon count is associated with the at least one radiation source;

receive from the at least fourth detector, at least a fourth radiation photon count determined by the at least fourth detector, wherein the at least fourth radiation photon count is associated with the at least one radiation source;

compare the third radiation photon count to the fourth radiation photon count;

determine, based at least on the first radiation photon count being compared to the second radiation photon count and the third radiation photon count being compared to the fourth radiation photon count, that the at least one radiation source is located in a direction in which contemporaneously

one of the first detector and the second detector is substantially facing, and

one of the third detector and fourth detector is substantially facing.

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